PERFORMANCE PIPE

A DIVISION OF CHEVRON PHILLIPS CHEMICAL COMPANY LP

Polyethylene Piping For Water Distribution and Transmission

Bulletin: PP 501

Municipal Water Distribution
Industrial Water Distribution
Raw and Potable Water
Water Transmission
Potable Water Fire Main

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High Density Polyethylene Piping For Water Distribution and Transmission

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Performance Pipe

PERFORMANCE PIPE is the functional successor to the operations of Plexco[1] and Driscopipe[2]. On July 1, 2000, Chevron Chemical Company and Phillips Chemical Company were joined to form Chevron Phillips Chemical Company LP. Performance Pipe, a division of Chevron Phillips Chemical Company LP, succeeds Plexco and Driscopipe as North America's largest producer of polyethylene piping products for gas, industrial, municipal, mining, oilfield, and utility applications.

Performance Pipe offers more than forty years of polyethylene piping experience, nine ISO Certified manufacturing facilities in eight states, and a manufacturing facility in Mexico.

Performance Pipe manufactures DriscoPlex® polyethylene piping products in sizes 1/2" through 54" outside diameter controlled pipe and tubing, and molded fittings.

To enhance the outstanding quality and performance of Performance Pipe polyethylene piping, Chevron Phillips Chemical Company LP further strengthens Performance Pipe with over four decades of quality polyolefin plastic resin production.

DRISCOPLEX® Piping for Water Distribution and Transmission

Polyethylene pressure pipe is used worldwide for water distribution and transmission systems as the preferred material of construction. DriscoPlex® OD-controlled, high-density polyethylene pipe and fittings have been developed specifically for water distribution and transmission. DriscoPlex® 4000 and DriscoPlex® 4100 high-density polyethylene piping components are made from pressure-rated PE 3408, extra-high molecular weight, high-density polyethylene material to provide an optimum balance of performance and properties to meet the stringent demands of today's municipal and industrial water distribution and transmission systems.

[1] Formerly - Plexco, a Division of Chevron Chemical Company
[2] Formerly - Phillips Driscopipe, A Division of Phillips Petroleum Company

August 2005 Supercedes all previous publications

Why Polyethylene Piping is Preferred for Water Distribution

DriscoPlex® 4000 and DriscoPlex® 4100 PE 3408 piping products for water distribution have outstanding performance features for municipal and industrial water distribution.

- High strength and stiffness to withstand long-term internal pressure and external loads.
- Long-term strength for extended life and performance.
- Resilience for enhanced resistance to recurrent and intermittent surge and water hammer.
- Flexible, tough, lightweight and impact resistant for lower cost installation, narrower trenches (reduced excavation)
- Fewer fittings required - Flexible PE pipe can be cold-bent in the field to follow contours and easements, reducing the need for fittings.
- DriscoPlex® 4000 and DriscoPlex® 4100 PE 3408 piping is the material of choice for horizontal directional drilling, plowing, river and water body crossings, pipe bursting, sliplining and other trenchless installation technologies.
- Chemical resistance to withstand corrosive chemicals (pH from I to 14), and aggressive soils.

- Does not rust, rot, corrode, tuberculate or support biological growth.
- Resistant to ultraviolet and thermal degradation.
- Can be connected using heat fusion, electrofusion, heat fusion saddles, mechanical couplings, flanges, mechanical-joint adapters and mechanical service and tapping saddles[3].
- Leak-tight heat fusion joints are fully restrained and as strong as the pipe itself.
- Retains flexibility even in sub-freezing temperatures - water can freeze in the pipe without damaging the pipe[4].
- Retains low resistance to liquid flows for reduced pumping and operating costs.

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[3]Performance Pipe recommended heat fusion procedures available upon request. Electrofusion devices should be installed in accordance with the device manufacturer's instructions. Stiffeners should be installed in the ID of the pipe end or plain-end fitting outlet when OD compression couplings are used. Install mechanical joining devices in accordance with the device manufacturer's instructions. Additional restraint may be required for mechanical joining devices that do not provide sufficient pullout resistance.

[4]Water can be frozen solid in polyethylene pipe without damaging the pipe, but an ice plug in the pipe will stop flow. *Do not apply pressure to a frozen line that has an ice plug*. Allow ice plugging to thaw before applying pressure to the line. Severe water hammer (such as from an ice plug stopping suddenly at an obstruction) in a frozen, surface or above grade pipeline can shatter the pipeline and flying fragments can cause death, injury or property damage.

- Standard colors for water service identification:
- DriscoPlex® 4000 and DriscoPlex® 4100 pipe can be tapped with standard tapping equipment and mechanical tapping saddles for HDPE pipe.
- Safe - no extractable additives or compounds that could compromise water quality - NSF Certification available.
- DriscoPlex® 4000 and DriscoPlex® 4100 pipe are manufactured in accordance with AWWA C906 and ASTM F 714 (Sizes > 4") .

Table 1 DRISCOPLEX® Color Identification

Series	IPS/DIPS	Standard Color Identification	Also Available
DRISCOPLEX ® 4000 pipe	DIPS	3 equally spaced pairs of blue stripes	Blue shell
DRISCOPLEX ® 4100 pipe	IPS	Black	4 equally spaced blue stripes or blue shell
DRISCOPLEX ® 1500 pipe	IPS	4 equally spaced red stripes (Not NSF approved)	4 equally spaced blue stripes (NSF approved)
DRISCOPLEX ® 1600 pipe	DIPS	3 equally spaced pairs of red stripes (Not NSF approved)	3 equally spaced pairs of blue stripes (NSF approved)

DriscoPlex® 4000 4" DIPS through 48" DIPS pressure pipe sizes are OD compatible with ductile iron pipe. DriscoPlex® 4100 3" IPS through 54" IPS pressure pipe sizes are OD compatible with steel pipe. DriscoPlex® 4000 and DriscoPlex® 4100 piping components are produced in four standard Pressure Classes - 80 psi, 100 psi, 130 psi and through 160 psi - for water at 73°F (23°C). Additional pressure classes below 80 psi and up to 255 psi are available depending upon pipe size. NSF Certification in accordance with NSF Standard 61 is available for potable water applications. DriscoPlex® Series water piping products are summarized on the following page.

[5] 3" pipe manufactured to AWWA C901 and ASTM F714; pipe < 3" manufactured to AWWA C901 and ASTM D3035.

Table 2 DRISCOPLEX® Piping Products for Municipal and Industrial Applications

Typical Markets for Pipe and Fittings	DRISCOPLEX® Series	Typical Features	Previous Designations	
			Former Plexco Product	Former Driscopipe Product
Water Distribution	DRISCOPLEX® 4000 pipe	5, 6	BLUESTRIPE™ (DIPS)	4000 BLUESHELL (DIPS)
	DRISCOPLEX® 4100 pipe	1, 2, 8	BLUESTRIPE™ (IPS)	4100 BLUESHELL (IPS)
Water Service Tubing	DRISCOPLEX® 5100 pipe	7	BLUESTRIPE™	5100 ULTRA-LINE®
FMR & NSF Approved Underground Fire Main	DRISCOPLEX® 1500 pipe	3	BLUESTRIPE™ FM	—
	DRISCOPLEX® 1600 pipe	4	—	—

NOTICE. Capabilities vary from manufacturing plant to manufacturing plant. Contact Performance Pipe to determine the availability of specific products and for the availability of particular stripe or shell colors, striping patterns, and IPS or DIPS sizing.

Legend for Typical Features:

1. IPS sizing system. Blue color stripes or blue color shell available on special order. The IPS longitudinal color stripe pattern is four equally spaced single color stripes extruded into the pipe OD.
2. 3" IPS – 28" IPS DR 11, 13.5, 17, 21; 30" IPS – 36" IPS DR 13.5, 17, 21; 42" IPS DR 17, 21; 48" IPS – 54" IPS DR 21
3. FMR Approved & NSF Approved. 2" IPS through 24" IPS Class 150 or Class 200. Blue color stripes standard. The IPS longitudinal color stripe pattern is four equally spaced single color stripes extruded into the pipe OD.
4. FMR Approved & NSF Approved. 4" DIPS through 24" DIPS Class 150 or Class 200. Blue color stripes standard. The DIPS longitudinal color stripe pattern is three equally spaced pairs of color stripes extruded into the pipe OD.
5. DIPS sizing system. Blue color stripes standard. The DIPS longitudinal color stripe pattern is three equally spaced pairs of color stripes extruded into the pipe OD.
6. 4" DIPS through 30" DIPS DR 11, 13.5, 17, 21; 36" DIPS through 40" DIPS DR 13.5, 17, 21; 48" DIPS DR 17, 21. All sizes made to ASTM F 714, AWWA C906 and NSF 61.
7. NSF Approved. CTS, IPS, and SIDR in 1/2" – 2" sizes. No color stripes.
8. 2" IPS and 3" IPS made to ASTM D 3035, AWWA C901 and NSF 61. 4" IPS and larger sizes made to ASTM F 714, AWWA C906 and NSF 61.

This bulletin primarily addresses DriscoPlex® 4000 and DriscoPlex® 4100 piping products. For information on DriscoPlex® 5100 piping products, see Bulletin PP503. For information on DriscoPlex® 1500 and DriscoPlex® 1600 FM Approved piping products, see Bulletin PP504.

Table 3 DRISCOPLEX® 4000 - DIPS Pipe Sizing System

Size		*DR 21 (80 psi PC†)*		*DR 17 (100 psi PC)*		*DR 13.5 (130 psi PC)*		*DR 11 (160 psi PC)*	
DIPS Pipe Size	*OD, in.*	*Minimum Wall, in.*	*Weight‡, lb/ft*	*Minimum Wall, in.*	*Weight, lb/ft*	*Minimum Wall, in.*	*Weight, lb/ft*	*Minimum Wall, in.*	*Weight, lb/ft*
4*	4.80	0.229	1.44	0.282	1.75	0.356	2.17	0.436	2.61
6	6.90	0.329	2.97	0.406	3.62	0.511	4.48	0.627	5.39
8	9.05	0.431	5.11	0.532	6.23	0.670	7.71	0.823	9.28
10	11.10	0.529	7.68	0.653	9.37	0.822	11.60	1.009	11.95
12	13.20	0.629	10.86	0.776	13.25	0.978	16.40	1.200	19.73
16	17.40	0.829	18.87	1.024	23.02	1.289	28.49	1.582	34.29
18	19.50	0.929	23.70	1.147	28.92	1.444	35.78	1.773	43.07
20	21.60	1.029	29.08	1.271	35.48	1.600	43.91	1.964	52.84
24	25.80	1.229	41.05	1.518	50.62	1.911	62.64	2.345	75.39
30††	32.00	1.524	63.83	1.882	77.86	2.370	96.38	2.909	115.99
36††	38.30	1.824	91.43	2.253	111.54	2.837	138.04		
42††	44.50	2.119	123.44	2.618	150.60	3.296	186.35		
48††	50.80	2.419	160.86	2.988	196.27				

† Pressure class ratings are for water at 80°F (27°C) or less. Pressure class ratings can vary for other fluids and service temperatures. * OD size and minimum wall thickness per AWWA C906. For flow calculations, average ID may be estimated using: Avg. ID = OD Size – (2.12 x min. wall). For actual ID (for stiffeners, etc.), consult AWWA C906 for tolerances and other factors affecting pipe ID. ‡ Pipe weight calculated per PPI TR-7. †† 30" DIPS and larger sizes subject to minimum order quantities.

Table 4 DRISCOPLEX® 4100 - IPS Pipe Sizing System

Size		DR 21 (80 psi PC†)		DR 17 (100 psi PC)		DR 13.5 (130 psi PC)		DR 11 (160 psi PC)	
IPS Pipe Size	OD, in.	Minimum Wall, in.	Weight‡, lb/ft	Minimum Wall, in.	Weight, lb/ft	Minimum Wall**, in.	Weight, lb/ft	Minimum Wall, in.	Weight, lb/ft
3*	3.500	0.167	0.77	0.206	0.93	0.259	1.15	0.318	1.39
4**	4.500	0.214	1.26	0.265	1.54	0.333	1.90	0.409	2.29
6	6.625	0.315	2.73	0.390	3.34	0.491	4.13	0.602	4.97
8	8.625	0.411	4.64	0.507	5.65	0.639	7.00	0.784	8.42
10	10.750	0.512	7.21	0.632	8.78	0.796	1.087	0.977	13.09
12	12.750	0.607	10.23	0.750	12.36	0.944	15.29	1.159	18.41
14	14.000	0.667	12.22	0.824	14.91	1.037	18.44	1.273	22.20
16	16.000	0.762	15.96	0.941	19.46	1.185	24.09	1.455	29.00
18	18.000	0.857	20.19	1.059	24.64	1.333	30.48	1.636	36.69
20	20.000	0.952	24.93	1.176	30.41	1.481	37.63	1.818	45.30
22	22.000	1.048	30.18	1.294	36.80	1.630	45.56	2.000	54.82
24	24.000	1.143	35.91	1.412	43.81	1.778	54.21	2.182	65.24
26††	26.000	1.238	42.14	1.529	51.39	1.926	63.62	2.364	76.55
28††	28.000	1.333	48.86	1.647	59.62	2.074	73.78	2.545	88.79
30††	30.000	1.429	56.12	1.765	68.45	2.222	84.69		
32††	32.000	1.524	63.84	1.882	77.86	2.370	96.35		
36††	36.000	1.714	80.78	2.118	98.57	2.667	121.98		
42††	42.000	2.000	109.97	2.470	134.15				
48††	48.000	2.286	143.65						
54††	54.000	2.571	181.80						

† Pressure class ratings are for water at 80°F (27°C) or less. Pressure class ratings can vary for other fluids and service temperatures. * 3" IPS OD and minimum wall thickness per AWWA C901. ** 4" IPS and larger OD and minimum wall thickness per AWWA C906. For flow calculations, Avg. ID may be estimated by: Avg. ID = OD Size – (2.12 x min. wall). Consult AWWA C906 for tolerances and other factors affecting actual pipe ID. ‡ Pipe weight calculated per PPI TR-7. †† 26" IPS and larger sizes subject to minimum order quantities.

Pressure Rating

Water system piping must be designed for the continuous internal pressure and for transient (surge) pressures imposed by the particular application. DriscoPlex® PE 3408 high-density polyethylene pipe provides a unique balance of properties that are especially well suited for water distribution and transmission. DriscoPlex® PE 3408 HDPE pipe has outstanding long-term strength that provides durability for long-term continuous internal pressure service. DriscoPlex® PE 3408 HDPE pipe also provides exceptional ductile elastic properties that provide exceptional fatigue resistance and reserve strength necessary for recurrent or intermittent pressure surges.

Continuous Internal Pressure

The continuous internal pressure, exclusive of transient pressure surges, is defined as "working pressure". A pipe's working pressure capacity is a function of the allowable hoop stress and pipe thickness. Allowable hoop stress is determined by testing plastic pipe at various internal pressures, analyzing the test data, and categorizing the result. The categorized result is defined as the hydrostatic design basis (HDB). The HDB is used in the pressure rating equations that follow.

Table 5 HDB for Performance Pipe PE 3408

Service Temperature	*Hydrostatic Design Basis, HDB*
73°F (23°C)	1600 psi (11.03 MPa)
140°F (60°C)	800 psi (5.52 MPa)

Pressure Surge

When there is a sudden increase or decrease in water system flow velocity, a pressure surge will occur. Recurrent pressure surges, P_{RS}, are repetitive surge events that occur frequently such as during pump start-stop operation. Occasional pressure surges, P_{OS}, are irregularly occurring surges such as a sudden flow change due to firefighting or check valve operation. Surge pressure magnitude corresponds directly to velocity change; greater velocity change produces greater surge pressure. The magnitude of a pressure surge due to a rapid flow velocity change may be approximated by the following equations:

$$P_S = \frac{aV}{2.31\,g} \qquad a = \frac{4660}{\sqrt{1 + \frac{K}{E}(DR - 2)}}$$

Where:

P_S	=	pressure surge, lb/in^2
a	=	wave velocity, ft/s
g	=	acceleration of gravity, 32.2 ft/s^2
V	=	flow velocity change, ft/s
E	=	instantaneous elastic modulus for PE, lb/in^2 (150,000 lb/in^2 for PE 3408 at $\leq$80°F)
K	=	liquid bulk modulus, lb/in^2 (300,000 lb/in^2 for water at $\leq$80°F)
DR	=	pipe dimension ratio

$$DR = \frac{OD}{t_{min}}$$

OD	=	pipe outside diameter, in
t_{min}	=	pipe minimum wall thickness, in

With its unique ductile elastic properties, flexibility, resilience and superb fatigue resistance, DriscoPlex® 4000 and DriscoPlex® 4100 pipes have tremendous tolerance for surge cycles. Its low elastic modulus provides a dampening mechanism for shock loads. These short-term properties result in lower surge pressures compared to more rigid systems such as steel, ductile iron or PVC. For the same velocity change in water piping systems, surge pressures in DriscoPlex® 4000 and DriscoPlex® 4100 polyethylene pipe are about 86% less than in steel pipe, about 80% less than in ductile iron pipe and about 50% less than in PVC pipe.

Unlike other plastic and metal pipes, surge pressures in DriscoPlex® 4000 and DriscoPlex® 4100 polyethylene pipe are handled above the working pressure capacity of the pipe.

Pressure Class (PC)

AWWA uses the term "Pressure Class" to define the pressure capacity under a pre-defined set of operating conditions. For polyethylene, the PC denotes the maximum allowable working pressure for water with a predefined allowance for pressure surges and a maximum pipe operating temperature of 80 °F.

$$PC = \frac{2 \times HDB \times DF}{(DR - 1)}$$

Where terms are previously defined and:

PC = pressure class, lb/in^2
HDB = hydrostatic design basis for PE 3408, lb/in^2 (Table 5)
DF = design factor (0.50 for clean water)

Table 6 shows Pressure Class ratings, surge allowance and corresponding allowable sudden change in flow velocity for standard DR's of DriscoPlex® 4000 and DriscoPlex® 4100 water pipe.

Table 6 Pressure Class, Surge Allowance and Corresponding Sudden Velocity Change for Pipe Operating at 80 °F

DR	PC, psi	Recurring Surge Events - P_{RS}		Occasional Surge Events - P_{OS}	
		Surge Allowance, P_{RS}, lb/in^2	Corresponding Sudden Velocity Change, ft/s	Surge Allowance, P_{OS}, lb/in^2	Corresponding Sudden Velocity Change, ft/s
21	80	40.0	4.0	80	8.0
17	100	50.0	4.4	100	8.9
13.5	128	64.0	5.0	128	10.0
11	160	80.0	5.6	160	11.1

For the vast majority of municipal systems, DriscoPlex® 4000 and DriscoPlex® 4100 polyethylene water pipe have considerably more surge and velocity capabilities than necessary, even under temporary high flow conditions such as flushing or fire-fighting.

- Surge allowance and temperature effects vary from pipe material to pipe material and erroneous conclusions may be drawn when comparing the PC of two different piping materials. For instance, the PC defined by AWWA for C900 PVC pipe includes a surge allowance corresponding to a flow velocity of 2 ft/sec. At flow velocities greater than 2 ft/sec, C900 PVC pipe should be de-rated. When both working pressure capacity and surge capacity are accounted for at velocities approaching 5 ft/sec, virtually the same DR is required for C906 PE and C900 PVC.

Working Pressure Rating (WPR)

As described, a pipeline containing flowing liquid is periodically subjected to two modes of hydrostatic stress: sustained stress from working pressure and transient stress from sudden water velocity changes. The pipe must be designed to handle both stress modes. As defined in AWWA Standards, Working Pressure Rating (WPR) is the capacity to resist working pressure (WP) with sufficient capacity against the actual anticipated positive pressure surges above working pressure. The only "pressure rating" the water distribution system designer should consider is the Working Pressure Rating, WPR. The sustained operating pressure applied to the pipe (working pressure) must be no greater than the WPR. Pressure Class and Working Pressure Rating are closely related. Pressure Class is a rating based on operating conditions that are predefined in the AWWA Standard, where WPR is calculated based on the anticipated operating conditions of the actual application. The predetermined Pressure Class from the AWWA Standard may or may not be appropriate for the actual application.

The following relationship between WP, WPR, and PC applies:

$$WP \leq WPR \leq PC$$

Working Pressure Rating for Typical Operating Conditions

When expected flow velocities are within the limits given in Table 6, and the pipe operates at 80 °F or less, the following equation applies:

$$WPR = PC$$

Working Pressure Rating for Other Operating Conditions

In applications where the pipe operates at temperatures above 80 °F or where exceptionally high flow demands exceed the PC surge allowance, WPR must be calculated. WPR is equal to the lesser of the following three conditions:

Condition 1 The pipe's nominal PC adjusted for temperature when above 80°F:

$$WPR = (PC)\,F_T$$

or

Condition 2 One and one half times the pipe's PC adjusted for temperature less the maximum pressure resulting from recurring pressure surges (PRS):

$$WPR = 1.5\,(PC)\,F_T - P_{RS}$$

or

Condition 3 Two times the pipe's PC adjusted for temperature less the maximum pressure resulting from occasional pressure surges (POS):

$$WPR = 2.0\,(PC)\,F_T - P_{OS}$$

Surge allowance, P_{RS} or P_{OS}, may be approximated using the equations in "Pressure Surge" above. As the equations show, operating at a working pressure less than the pipe's nominal PC provides additional surge pressure capacity.

Temperature reduction factors, FT, are presented in Table 7. (See following page)

Table 7 Temperature Factor, F_T

Service Temperature, °F (°C)	≤ 80 (27)†	≤ 90 (32)	≤ 100 (38)	≤ 110 (43)	≤ 120 (49)	≤ 130 (54)	≤ 140 (60)‡
Temperature Factor, F_T	1.00	0.90	0.78	0.75	0.63	0.60	0.50
† Use 80°F (27°C) service factor for 80°F (27°C) and lower service temperatures. ‡ The maximum service temperature for DRISCOPLEX® PE 3408 pressure pipe is 140°F (60°C).							

Water Flow

DriscoPlex® 4000 and DriscoPlex® 4100 piping has unique surface properties that reduce flow resistance, and help retain reduced flow resistance properties over the long term. HDPE has a wax-like, water repellent surface that does not rust, rot, corrode, tuberculate or support biological growth. Turbulence at moderate flow velocities helps prevent deposition and sedimentation to help retain long-term reduced flow resistance and reduce the need for maintenance flushing.

Designers use various methods to determine flow resistance. For traditional flow resistance equations developed by Darcy-Weisbach, Fanning, Colebrook, and Moody, an absolute roughness of 5 x 10^{-6} ft. (1 x 10^{-8} m) is typically used in design. For the empirical Hazen-Williams formula (given below), a C-Factor of 150-155 is typically used in design.

$$h_f = 0.002083\, L \left(\frac{100}{C}\right)^{1.85} \left(\frac{Q^{1.85}}{d^{4.8655}}\right)$$

$$p_f = 0.0009015\, L \left(\frac{100}{C}\right)^{1.85} \left(\frac{Q^{1.85}}{d^{4.8655}}\right)$$

Where h_f = friction (head) loss for water, ft.
- L = pipe length, ft.
- C = C-Factor
- Q = flow, gal/min
- d = pipe inside diameter, in.
- p_f = friction loss for water, psi

Joining

DriscoPlex® Series HDPE pipe and fittings are joined using heat fusion, flanges, mechanical connections that are designed for PE pipe, and electrofusion. Heat fusion is a simple, visual procedure that utilizes controlled temperature and pressure to melt and fusion-join PE pipe materials together. Butt fusion is used to join components end to end; saddle fusion to attach a branch outlet to a main pipe, and socket fusion to join smaller pipes to socket fittings. Heat fusion joints are reliable, leak-free, fully restrained, and as strong as the pipe itself. Contact Performance Pipe for recommended joining procedures.

With heat fusion, there are no gaskets to leak, joint restraints are not required, and thrust blocks are necessary only under unusual circumstances. A leakage allowance common to gasketed-bell-and-spigot joined pressure pipes is unnecessary with the Performance Pipe PE 3408 pressure piping system. Heat fusion joints are fully restrained and as strong as the pipe itself. Because water flow pressure cannot push heat fusion joined off the pipe end, thrust blocks are not required. Thrust anchoring may be required to control Poisson effect forces where PE pipes are connected to bell and spigot piping.

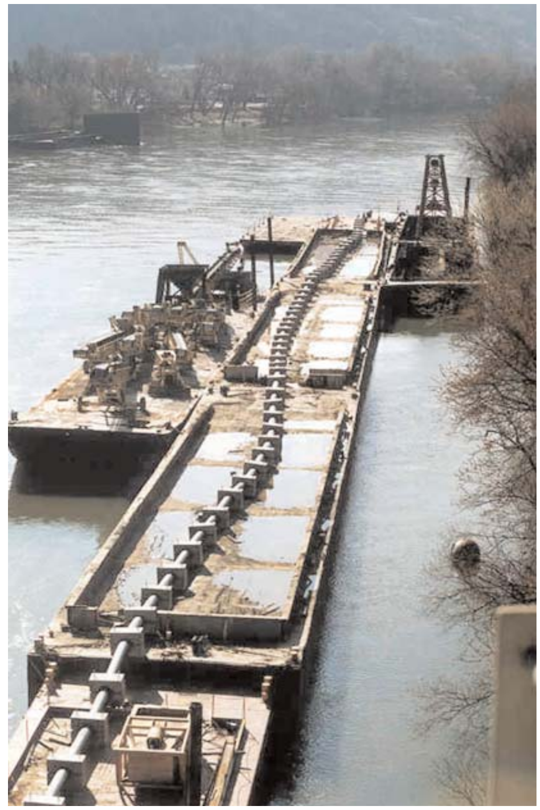
Performance Pipe PE 3408 pipe and fittings may also be joined together or transitioned to other materials with flanges, mechanical connections that are designed for PE pipe, or electrofusion. These connections must be made in accordance with the connection manufacturer's instructions. Some connections such as mechanical OD compression couplings may require a stiffener in the pipe bore.

DriscoPlex® Series HDPE piping products cannot be joined with adhesive or solvent cement. Threaded joining and joining by hot air (hot gas) or extrusion welding techniques are not recommended for pressure service.

Tapping

DriscoPlex® 4000, DriscoPlex® 4100, DriscoPlex® 1500 and DriscoPlex® 1600 piping systems may be tapped with conventional water main tapping equipment. The tapping operation is essentially the same as that used for any water main. A tapping sleeve for HDPE pipe is installed on the main, an open tapping valve is connected to the sleeve, and then a tapping machine is connected to the valve. A rotating shell cutter in the tapping machine is advanced through the pipe wall, and then retracted. The valve is closed and the tapping machine is removed. Branch line piping is then connected to the valve. When the main is not pressurized, the valve can be omitted. For HDPE piping, the tapping machine shell cutter has few teeth and large chip clearance between the teeth.

Installation



DriscoPlex® 4000 and DriscoPlex® 4100 piping materials are stabilized against UV degradation and can be permanently installed on or above the surface[6]. Surface and above grade applications must be properly supported, and must take thermal expansion and contraction into account. If the external environment subjects the line to freezing conditions, water in the pipe may freeze, however, the pipe will expand as the ice forms and will not break. To prevent freezing, the line may be insulated and may be heat traced if necessary. Heat tracing equipment should not exceed 120°F (49°C).

Although DriscoPlex® 4000 and DriscoPlex® 4100 piping can be installed on or above grade, most water applications are installed underground. (DriscoPlex® 1500 and DriscoPlex® 1600 piping must be installed underground.) Installation methods include direct burial, horizontal directional drilling, pulling, plowing and planting.

DriscoPlex® 4000 and DriscoPlex® 4100 piping are also used to rehabilitate existing pipelines. Rehabilitation techniques include sliplining, pipe bursting, and proprietary techniques for installing tight-fitting liners.

Direct Burial

Direct burial involves opening a trench, laying the pipe in the trench, then backfilling with appropriate materials. Pipes are joined into long strings before placing them in the trench. DriscoPlex® 4000 and DriscoPlex® 4100 pipes should be installed in accordance with ASTM D 2774 *Standard Practice for Underground Installation of Thermoplastic Pressure Piping.*

Like all piping materials, HDPE piping must be properly installed. HDPE is a flexible piping material that works together with its soil embedment to sustain the earthloads and live loads above it. Suitable embedment soils are required to provide support around the pipe, and embedment soils must be placed so that the pipe is properly surrounded in embedment materials. In general, coarse, angular sands and gravels are preferred, but other materials may be used under the direction of the design engineer. See ASTM D 2774 for embedment material size. Embedment materials must be placed in the haunch areas below the pipe springline and above the pipe so that the pipe is fully encapsulated without voids in the embedment. Compacted embedment is preferred. See the *Performance Pipe Engineering Manual* for information about the design of underground installations.

[6]DriscoPlex® 4000 and DriscoPlex® 4100 piping with a blue shell should not be used for on or above surface applications. These products are UV stabilized to allow unprotected outdoor storage for up to 18 months.

Horizontal Directional Drilling

Horizontal directional drilling is a technique for installing pipes and utility lines below ground using a surface-mounted drill rig that launches and places a drill string at a shallow angle to the surface and has tracking and steering capabilities. When the drill is advanced underground, it creates a borehole along its path. As the destination is reached, the drill string is angled upwards to penetrate the surface. After the borehole has been opened, a backreamer is attached to the head of the drill string, and the HDPE pipe is attached to the backreamer. The drill string is then retracted. During retraction, the borehole is expanded by the backreamer and the HDPE pipe is drawn into the borehole. To protect HDPE pipe against excessive pulling load, a weak-link or breakaway device should always be used at the head of the HDPE pipe. The allowable tensile load for setting weak-link devices is determined using ASTM F 1804 *Standard Practice for Determining Allowable Tensile Load for Polyethylene (PE) Gas Pipe During Pull-In Installation.* Horizontal Directional Drilling (HDD) applications should be installed in accordance with ASTM F1962 *Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacle, Including river Crossings, Plastic Pipe Institute (PPI) Polyethylene Pipe for Horizontal Directional Drilling, and the Mini Horizontal Directional Drilling Manual published by the North American Society of Trenchless Technology (NASTT)*. Additional information is available in Performance Pipe Technical Note PP-800 HDD - *Horizontal Directional Drilling.*

Planting, Plowing and Pulling

Planting and plowing are limited to suitable soils and site conditions. In planting, wheel or chain type trenchers are used to cut a narrow, round bottom trench. A long pipe string or pipe from a coil is fed over the trencher and directly into the trench. Backfilling follows after trenching and laying. In plowing, a plow rather than a trencher is used to open the trench. The plow may be fitted with a chute to feed pipe down through the plow into the trench bottom. The minimum bend radius for the pipe feed plow chute is 10 times the pipe OD. Flexible HDPE pipe is ideal for these installations.

Pulling involves opening a trench then pulling the pipe into the trench from one end. Sometimes a truck is fitted with an outrigger that extends over and down into the trench. The pipe is attached to the outrigger and then the truck is driven along the trench to drag the pipe into the trench. As with horizontal directional drilling, the pipe should always be protected with a weak-link or breakaway device at the leading end.

Rehabilitation

In sliplining, a slightly smaller pipe is pulled or pushed inside the old pipe. Typically, the new pipe must be at least 10% smaller in outside diameter than the inside diameter of the host pipe. The host pipe must be depressurized and cleaned, and tight bends removed. A sloped entrance pit is excavated, and a section of the top of the host pipe is removed. Then the new pipe is pushed or pulled or push-pulled into the host pipe. Once installed, the new pipe is connected to the system at both ends. In many cases, the improved flow characteristics of DriscoPlex® 4000 and DriscoPlex® 4100 HDPE pipe can deliver flows comparable to the original capacity, even though the new pipe is smaller. See ASTM F 585 *Standard Practice for Insertion of Flexible Liners into Existing Sewers*.

In pipe bursting, preparations are similar to pull-in sliplining, but a bursting head is placed ahead of the new pipe. The bursting head breaks the host pipe into fragments so an equal size or larger new pipe can be pulled inside. Pipe bursting is limited to host pipes that can be fragmented.

Other rehabilitation techniques include tight-fitting liners where proprietary techniques are used to install liner inside the host pipe in intimate contact with the host pipe ID. These proprietary techniques typically use a mechanical procedure such as rollers, swaging or deformation into a u-shape to reduce the diameter of a liner. It is then installed inside the host pipe similar to sliplining, and then re-expanded against the host pipe ID using various means to revert the liner pipe to its original diameter[7].

After Installation

Post installation procedures generally include leak testing and disinfecting for potable water lines.

Leak Testing

Take all necessary precautions to ensure the safety of persons and property while conducting leak tests. Leak tests should always be conducted using hydrostatic leak testing procedures. In general, the maximum allowable test pressure for leak testing is 150% of the pipe working pressure at the lowest elevation in the line; the maximum time allotted to conduct a leak test is eight (8) hours including bringing the line up to pressure, maintaining test pressure, and depressurizing; if leaks are found, depressurize the line before repairs are made; and if retesting is necessary, allow the line to relax for at least eight (8) hours before repressurizing the line. See Performance Pipe Technical Note PP-802 *Leak Testing for recommended leak testing procedures.*

WARNING - Correctly made fusion joints do not leak. When pressurized, leakage at a faulty fusion joint may immediately precede catastrophic separation and result in violent and dangerous movement of piping or parts and the release of pipeline contents under pressure. Never approach or attempt to repair or stop leaks while the pipeline is pressurized. Always depressurize the pipeline before making corrections. Faulty fusion joints cannot be repaired.

Disinfecting

Applicable procedures for disinfecting new and repaired potable water mains are presented in standards such as ANSI/AWWA C651 *Disinfecting Water Mains*. ANSI/AWWA C651 uses liquid chlorine, sodium hypochlorite or calcium hypochlorite to chemically disinfect the main. Disinfecting solutions must not exceed 12% active chlorine because greater concentration can chemically attack and degrade polyethylene. After disinfecting, all disinfecting solution must be flushed from the system, especially from dead-end lines.

[7]Because some proprietary tight-fitting liner installation techniques can impose high stresses on a polyethylene liner, the installer should provide validation data and information, and should certify the long-term performance of the installed liner.

Repairs

Damage generally requires replacing the damaged section. With larger pipes, replacing the damaged section with a flanged section of pipe is usually necessary. Smaller pipes may be flexible enough to fuse a replacement pipe section at one end, and then deflect the other end to the side so a fully restrained mechanical coupling or electrofusion fitting can be installed.

Temporary repairs to seal minor leaks or punctures, or to reinforce damaged areas until permanent repairs can be performed typically employ a full encirclement repair clamp. Polyethylene pressure pipe cannot be repaired or restored to full service capacity using extrusion or hot air welding to fill or plug damaged areas.

Cautions

Observe all local, state and federal codes and regulations, and general handling, installation, construction and operating safety precautions. The following are some additional precautions that should be observed when using Performance Pipe polyethylene piping products.

Fusion and Joining

During heat fusion, equipment and products can exceed 400°F (204°C). Take care to prevent burns.

Do not bend pipes into alignment against open butt fusion machine clamps. The pipe may spring out and cause injury or damage.

Performance Pipe polyethylene piping products cannot be joined with adhesive or solvent cement. Pipe-thread joining and joining by hot air (gas) welding or extrusion welding techniques are not recommended for pressure service.

Liquid hydrocarbon permeation may occur when liquid hydrocarbons are present in the pipe, or where soil surrounding the pipe is contaminated with liquid hydrocarbons. Permeated polyethylene pipe should be joined using suitable mechanical connections because fusion joining to liquid hydrocarbon permeated pipes may result in a low strength joint. Mechanical fittings must be installed in accordance with the fitting manufacturer's instructions. Obtain these instructions from the fitting manufacturer. See Performance Pipe Bulletin PP 750 and the *Performance Pipe Engineering Manual.*

Weight, Unloading and Handling

Although polyethylene piping is lightweight compared to some other piping products, significant weight may be involved. Move polyethylene piping with proper handling and lifting equipment. Use fabric slings. Do not use chains or wire ropes. Do not roll or drop pipe off the truck, or drag piping over sharp rocks or other abrasive objects. Improper handling or abuse can damage piping and compromise system performance or cause injury or property damage. ***Obtain and observe the handling instructions provided by the delivery driver.***

Striking the pipe with an instrument such as a hammer may result in uncontrolled rebound. Store DriscoPlex® products so that the potential for damage or injury is minimized. See the *Performance Pipe Engineering Manual.*

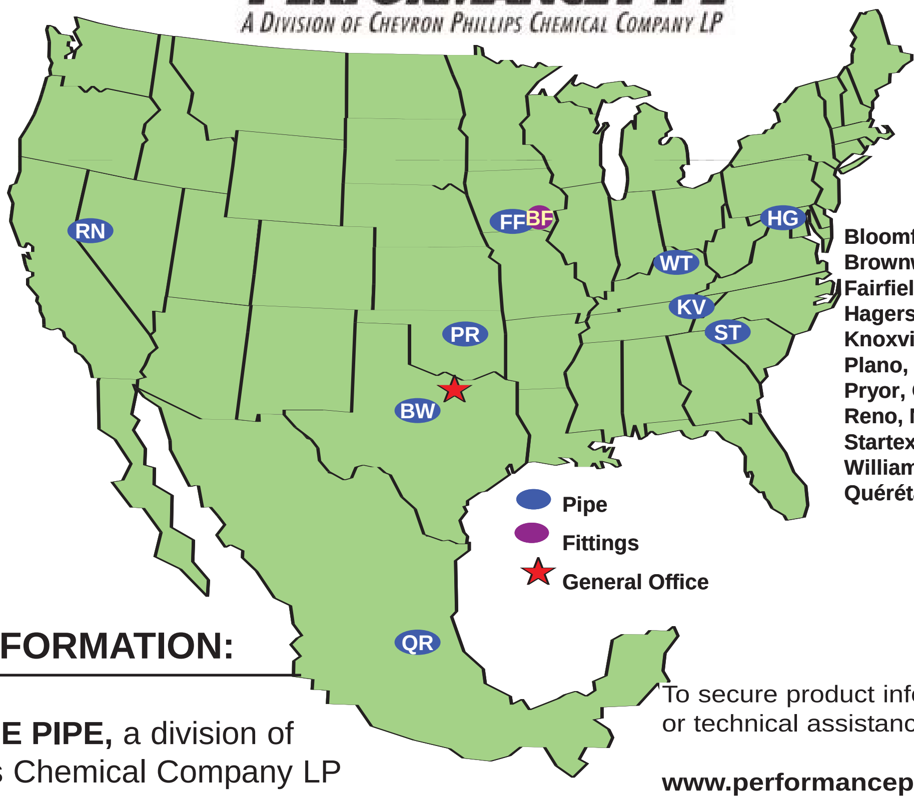
Testing

When testing is required, observe all safety measures, restrain pipe against movement in the event of catastrophic failure, and observe limitations of temperature, test pressure, test duration and making repairs. See Performance Pipe Technical Note PP-802 *Leak Testing PE Piping Systems.*

Protection Against shear and Bending Loads

Where a polyethylene branch or service pipe is joined to a branch fitting and where pipes enter or exit casings or walls, structural support such as properly placed, compacted backfill and a protective sleeve should be used. Whether or not a protective sleeve is installed, the area surrounding the connection must be structurally supported by embedment in properly placed compacted backfill or other means to protect the polyethylene pipe against shear and bending loads. See the Performance Pipe Engineering Manual and ASTM D 2774.

PERFORMANCE PIPE
A Division of Chevron Phillips Chemical Company LP



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Product Literature
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Technical Notes & Bulletins*:

Bulletin: PP 502	Polyethylene Piping for Sewer Rehabilitation
Bulletin: PP 503	Municipal and Industrial Brochure
Bulletin: PP 109	PE 3408 Data Sheet
Bulletin: PP 152	Municipal & Industrial Size and Dimension Sheet - IPS
Bulletin: PP 153	Municipal & Industrial Size and Dimension Sheet - DIPS
Bulletin: PP 750	Performance Pipe General Fusion Brochure
Bulletin: PP 900	Performance Pipe Engineering Manual

* Additional product literature will be available upon completion. Visit Performance Pipe on the web for the latest completed literature.